NIC 11293

ASS NOTE 11

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BBN
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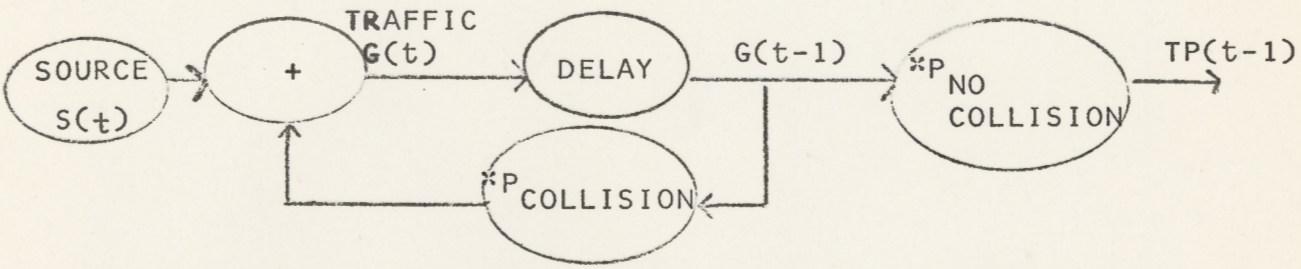
A BRIEF SIMULATION OF THE DYNAMICS OF AN ALOHA SYSTEM WITH SLOTS

We have done a simple simulation of an ALOHA packet system with slots. The basic model for this is:



where: S(t), G(t), G(t-1), TP(t-1) are fractions of the channel, and $P_{collision}$ is a function of the channel traffic.

This model produces the following recursion relation:

$$G(t) = S(t) + P_{collision} * G(t-1)$$

and additional relations are:

Throughput: $TP(t) = G(t)\ P_{no\ collision}$

Normalized Delay:

$$Delay = \frac{1}{P_{no\ collision}}$$

Assumptions:

Implicit in our model are several known assumptions, and certainly others of which we are unaware.

- The channel is error-free.
- All sources are combined into one source rate.
- All messages are the length of the time slot.

- No overheads are included.
- Retransmission packets do not have to be delayed to reenter the channel at a random time.
- Length of time to transmit packets is considered negligible as compaired to satellite round-trip delay.
- Messages never have to wait in an IMP before they are transmitted.

Probability of collision:

As in ASS Note 8:

$$\text{Prob.(no collision,t)} = e^{-G(t)}$$

$$P(\text{collision,t}) = 1 - e^{-G(t)}$$

Channel capacity:

By the above, the recursion relation we use is

$$G(t) = S(t) + G(t-1)\,[1 - \exp(-G(t-1))]$$

in steady state,

$$TP = S = Ge^{-G}$$

which yields maximum throughput when G = 1 and the capacity is:

$$\text{capacity} = \frac{1}{e} = .36$$

Still considering steady state, we may ask what happens to the channel traffic for a course rate less than the capacity.

Referring to Figure 2, we can see that for any source rate less than the capacity (.36), there are two possible values for the traffic—one for G<1, and one for G>1. These two solutions are both equilibrium solutions; however, those with G<1 are stable, and those with G>1 are unstable. We will see exactly what this means when we consider the channel dynamics.

The simulation:

In the following pictures,

% = throughput

+ = prob. of collision

Note: Throughput plus prob. of collision = total utilization

The solid line indicates the source waveform.

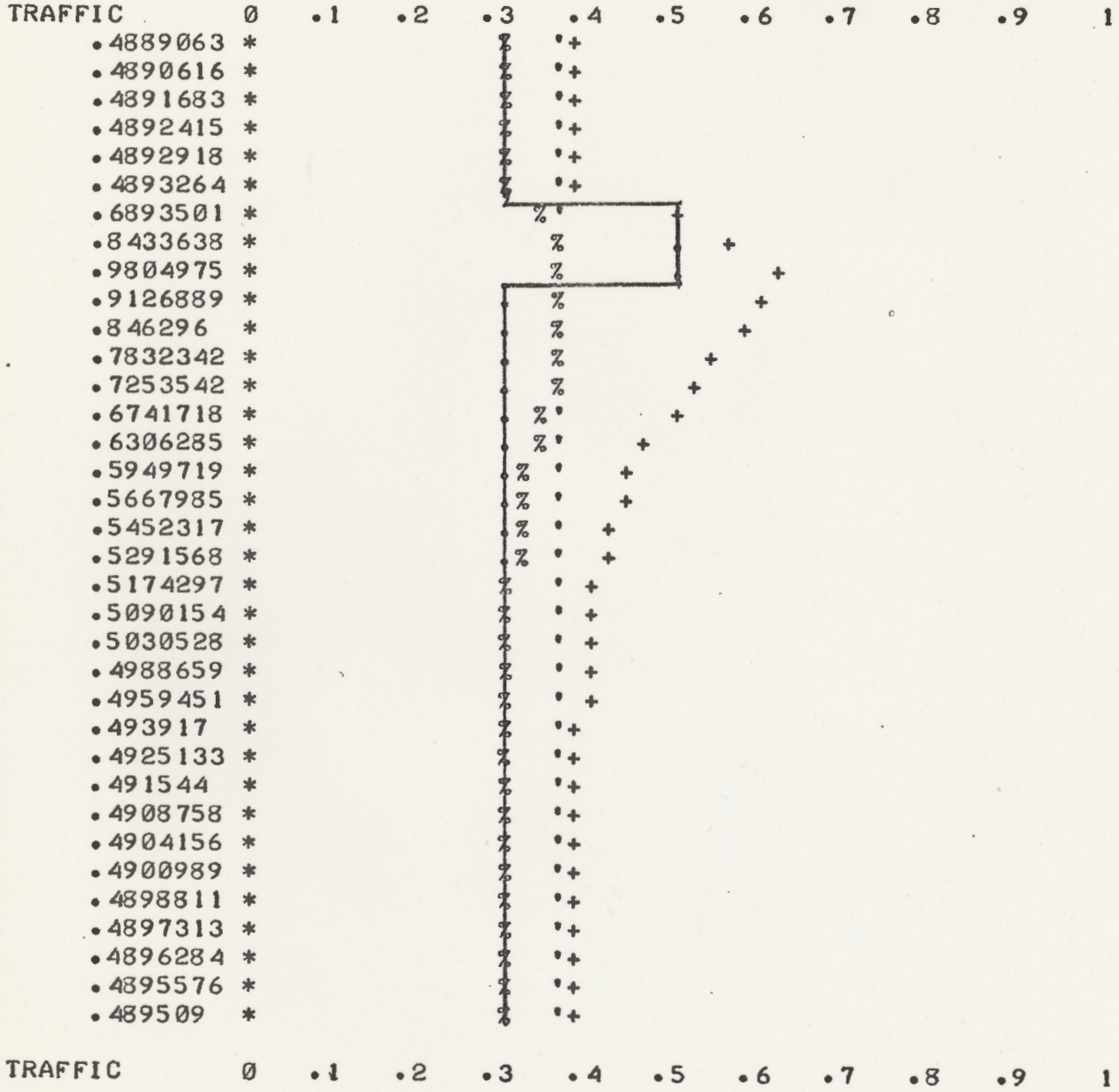
Contents:

- A normal operation of the channel.
- Four graphs of what happens when the traffic enters the unstable region.
- The low utilization case.

DYNAMICS OF A SLOTTED ALOHA SATELLITE SYSTEM

PART I: VALUE OF SOURCE= .3 DURATION= 6
PART II: VALUE OF SOURCE= .5 DURATION= 3
PART III: VALUE OF SOURCE= .3 DURATION= 25

% = THROUGHPUT . = SOURCE RATE
\+ = PROB. OF COLLISION ' = 1/E OR THEORETICAL CAPACITY



THIS ILLUSTRATES THE RESULT OF AN AVERAGE SOURCE RATE BELOW CAPACITY, WITH A SIGNIFICANT BURST ABOVE CAPACITY.

FIG. 1

STEADY STATE TRAFFIC VS SOURCE RATE
FOR A SLOTTED ALOHA SYSTEM

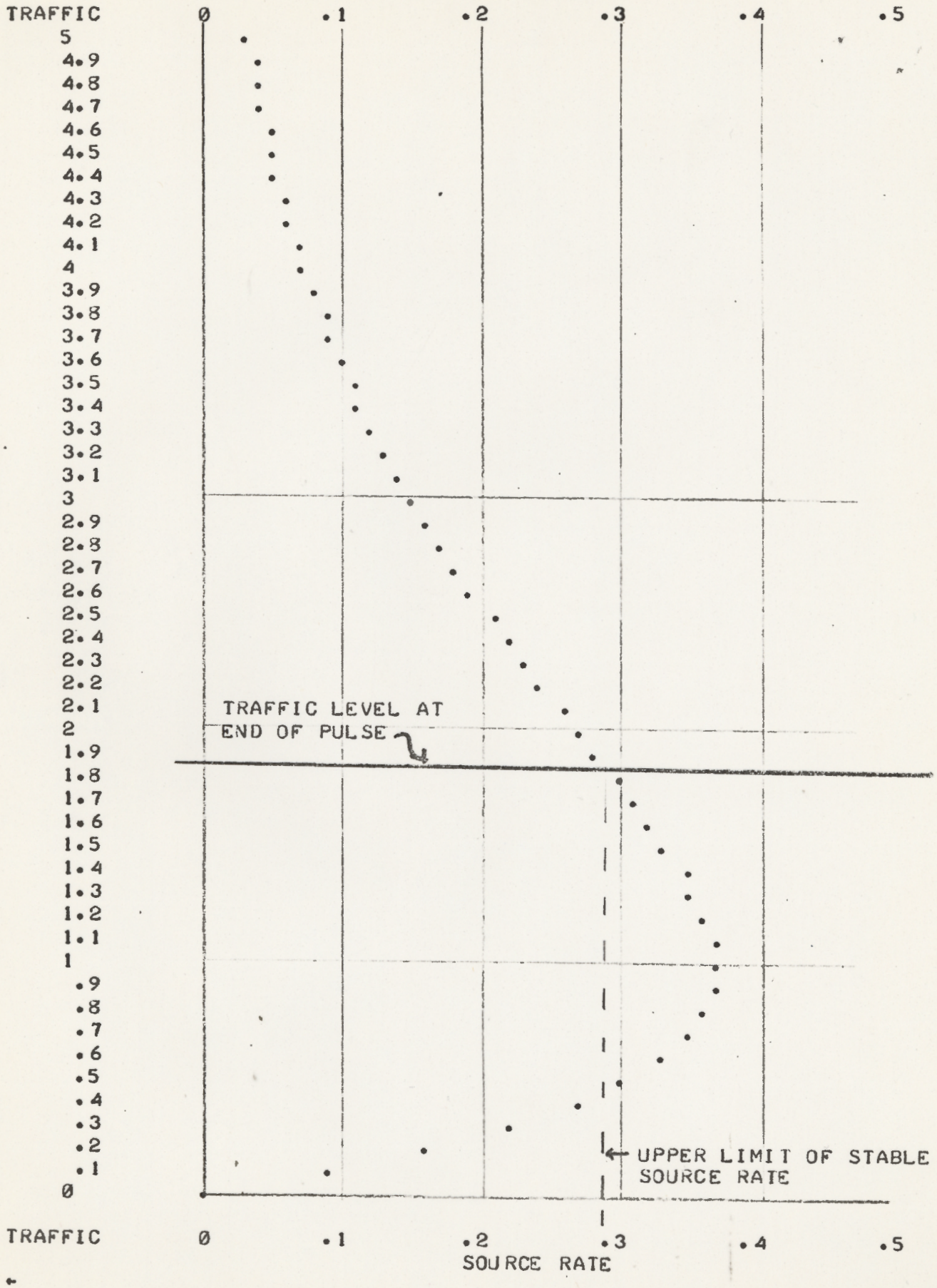
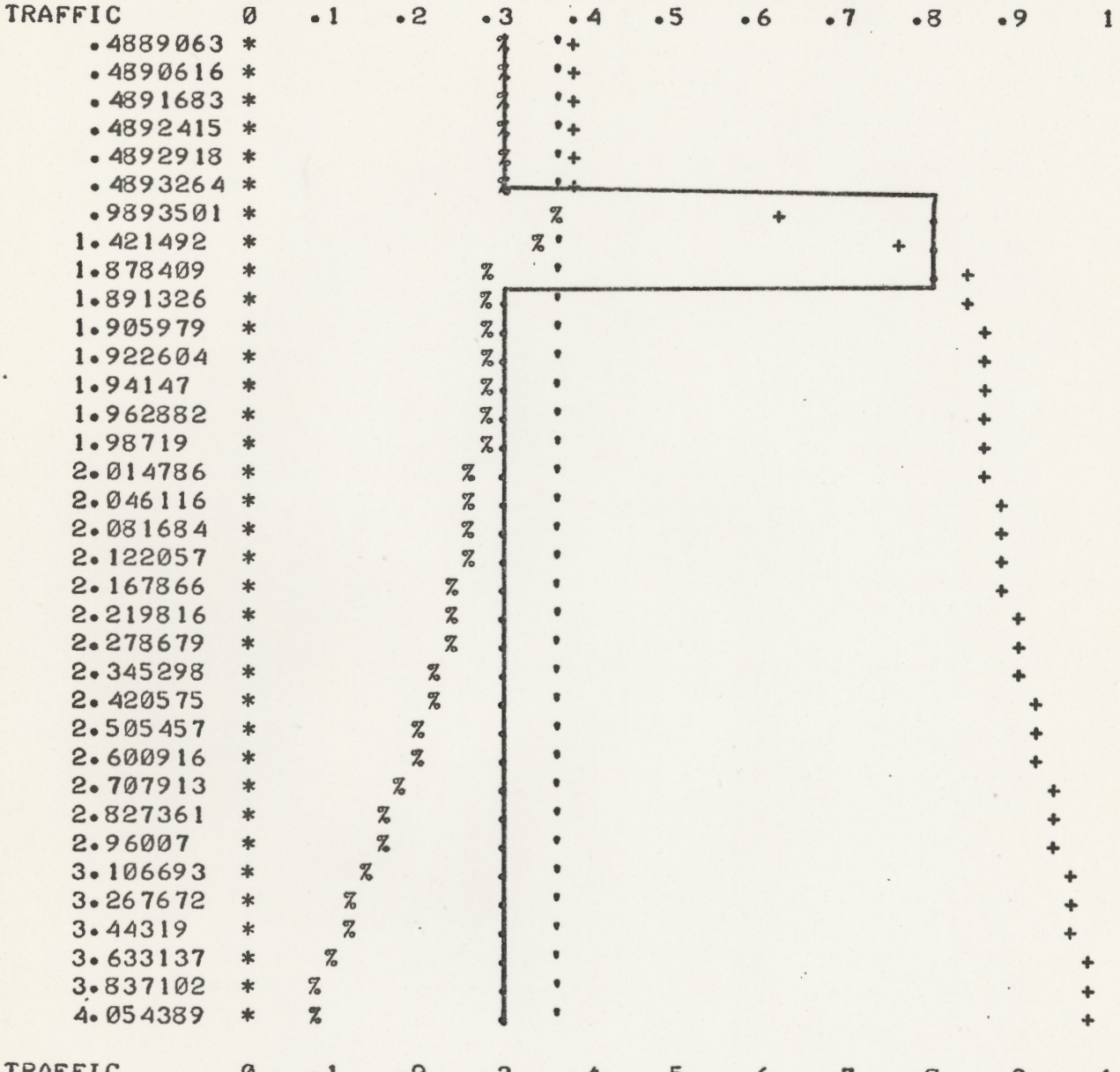


FIG 2.

DYNAMICS OF A SLOTTED ALOHA SATELLITE SYSTEM

PART I: VALUE OF SOURCE= .3 DURATION= 6
PART II: VALUE OF SOURCE= .8 DURATION= 3
PART III: VALUE OF SOURCE= .3 DURATION= 25

% = THROUGHPUT . = SOURCE RATE
\+ = PROB. OF COLLISION ' = 1/E OR THEORETICAL CAPACITY

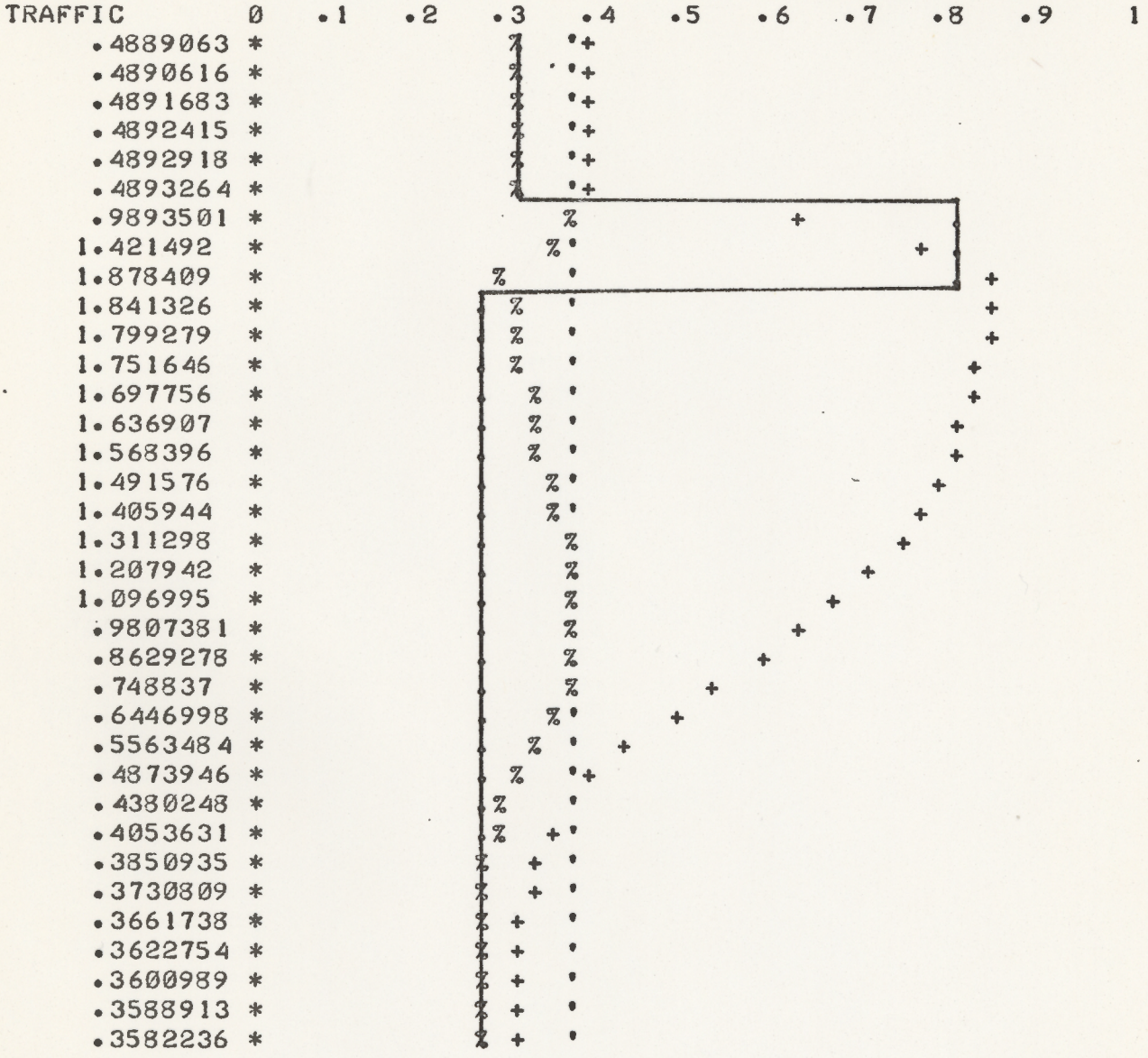


IN THIS CASE, THE BURST DRIVES THE SYSTEM INTO THE "UNSTABLE" REGION, AND THE SOURCE RATE AFTER THE BURST IS TOO LARGE.

DYNAMICS OF A SLOTTED ALOHA SATELLITE SYSTEM

PART I: VALUE OF SOURCE= .3 DURATION= 6
PART II: VALUE OF SOURCE= .8 DURATION= 3
PART III: VALUE OF SOURCE= .25 DURATION= 25

% = THROUGHPUT . = SOURCE RATE
+ = PROB. OF COLLISION ' = 1/E OR THEORETICAL CAPACITY

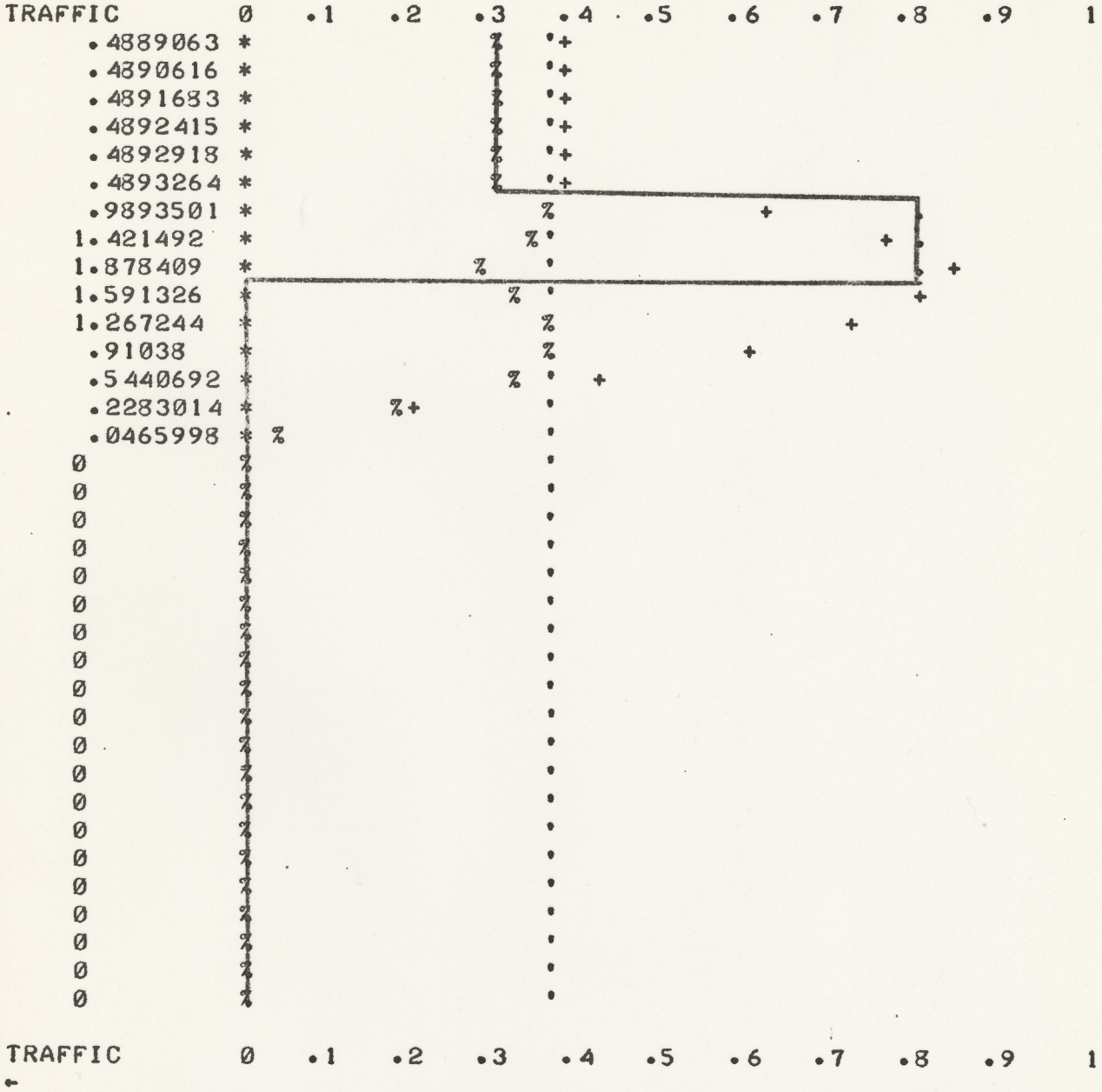


AS THIS ILLUSTRATES, THE SYSTEM WILL RETURN TO NORMAL OPERATION (GRANTED AFTER A LONG DELAY DUE TO THE HIGH RATE AFTER THE BURST) IF THE SOURCE RATE IS RETURNED TO A VALUE BELOW THE 'UPPER LIMIT OF STABLE SOURCE RATE' AS INDICATED BY THE STEADY-STATE GRAPH

DYNAMICS OF A SLOTTED ALOHA SATELLITE SYSTEM

PART I: VALUE OF SOURCE= .3 DURATION= 6
PART II: VALUE OF SOURCE= .8 DURATION= 3
PART III: VALUE OF SOURCE= 0 DURATION= 25

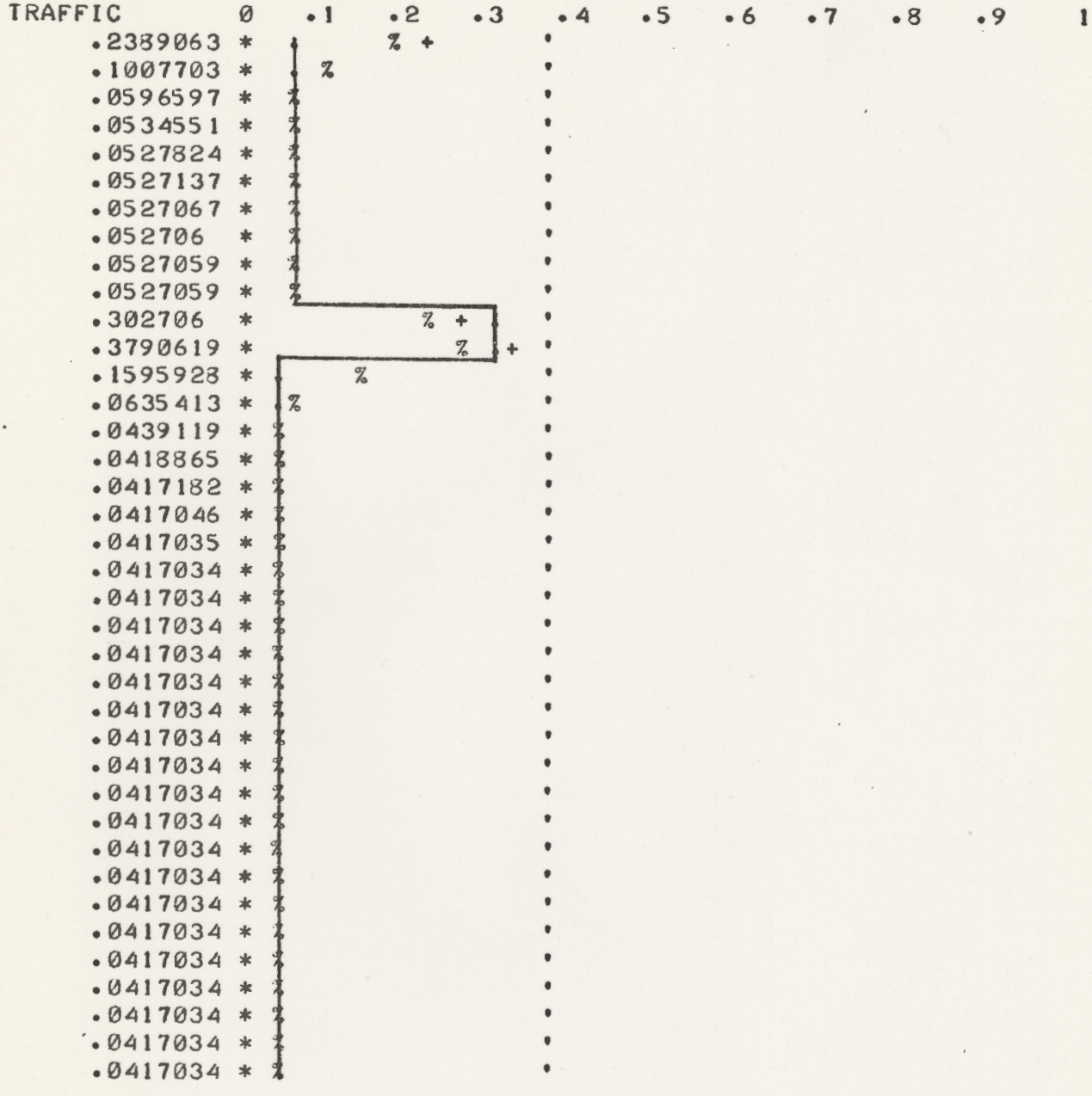
% = THROUGHPUT . = SOURCE RATE
\+ = PROB. OF COLLISION ' = 1/E OR THEORETICAL CAPACITY



THIS ILLUSTRATES HOW FAST RECOVERY FROM THE "UNSTABLE" REGION CAN BE IF THE SOURCE RATE DROPS TO ZERO AFTER THE BURST.

PART I: VALUE OF SOURCE= .05 DURATION= 10
PART II: VALUE OF SOURCE= .3 DURATION= 2
PART III: VALUE OF SOURCE= .04 DURATION= 25

% = THROUGHPUT . = SOURCE RATE
+ = PROB. OF COLLISION ' = 1/E OR THEORETICAL CAPACITY



THIS ILLUSTRATES HOW WELL BEHAVED THE SYSTEM IS IF THE

AVERAGE CHANNEL UTILIZATION IS SMALL

DYNAMICS OF A SLOTTED ALOHA SATELLITE SYSTEM

PART I: VALUE OF SOURCE= .1 DURATION= 15
PART II: VALUE OF SOURCE= .5 DURATION= 5
PART III: VALUE OF SOURCE= .1 DURATION= 20

% = THROUGHPUT . = SOURCE RATE
+ = PROB. OF COLLISION ' = 1/E OR THEORETICAL CAPACITY